Water Quality

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WOTS Reservoir Erosion Control and Revegetation Workshop and Demonstration

Smithville Lake, Smithville, Missouri

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Problem

The U.S. Army Corps of Engineers manages natural resources in more than 2,000 watersheds in the United States. These include about 460 water resource development projects (primarily reservoirs) where nearly 12 million acres of land and water are owned in public trust. According to a survey by Allen and Wade (1991) under the Water Operations Technical Support (WOTS) Program, many of these reservoirs have a considerable amount of shoreline erosion that can adversely impact aquatic and riparian habitats as well as numerous other factors, such as water quality. Most of the extreme erosion problems can be found in Corps Divisions and Districts having reservoirs within the central prairie zones of the United States. Missouri is one state containing reservoirs with such problems and Smithville Lake, Missouri, is one example.

Smithville Lake, Clay County, Missouri, has extensive shoreline erosion due in part to wind-driven waves, boat waves, and fluctuating water levels. As a result, vegetation has had difficulty establishing and maintaining itself along these shorelines. In turn, fisheries and wildlife habitat along these shorelines is also somewhat limited in certain areas according to the Missouri Department of Conservation (MDC), a partner with the U.S. Army Engineer District, Kansas City, in managing fish and game within the reservoir boundary. Stabilization methods, such as bioengineering, can be used to control shoreline erosion and improve habitat and water quality conditions. Bioengineering is the combination of biological, mechanical, and ecological concepts to control erosion and stabilize soil either through the use of vegetation or a combination of vegetation and construction materials (Allen and Leech 1997).

Approach

In the spring of 1997, WES was invited by the Kansas City District and the MDC to assess the above problem at Smithville Lake and formulate an approach that would emphasize bioengineering. Because both the Kansas City District and MDC had other reservoirs with similar problems, the WOTS Program was asked to cosponsor and cofund a reservoir erosion control and revegetation workshop with a demonstration for "hands-on" training so that bioengineering technology could be applied at both Smithville and other lakes with similar problems. Both the Kansas City District and the MDC would contribute either direct funding or in-kind services to the project, with other funding coming from the WOTS Program.

The proposal was approved by the WOTS Program. A workshop and demonstration took place March 9-13, 1998, with 33 participants, about half from the Kansas City District and half from the MDC. After about 1-1/2 days of classroom instruction, the students had another 1-1/2 days of hands-on training at a field demonstration site. The group was divided into four rotating teams for work on various bioengineering treatments that spanned almost 600 linear ft of shoreline.

Demonstration Area

The 600-ft reach of shoreline was located in the Camp Branch arm of the lake on a peninsula that receives moderate wind-driven wave attack from the northwest with about a 1/2-mile fetch. Eroded banks revealed escarpments ranging from 1 to 3 ft high. The reach that contained the treatments received differential wave attack and influenced the methodology. Generally speaking, the farther one proceeded onto the peninsula, the more wave energy could be expected due to greater exposure to the prevailing wind as a result of shoreline geometry. Consequently, the demonstration was divided into four treatments with two of those containing wave breakwater structures and two containing none. The two with wave breakwater structures were placed farther out on the peninsula (westernmost end), while those two treatments without the structures were placed farther in on the peninsula (easternmost end). The latter two treatments relied on anchoring plants by securing them with: 1) rolls of fastened burlap filled with soil called plant-rolls; 2) nonwoven geotextile erosion control mats; or 3) nothing, relying only on the plant to grow fast enough to attach itself to the substrate through its morphological features such as rhizomes and adventitious sprouts.

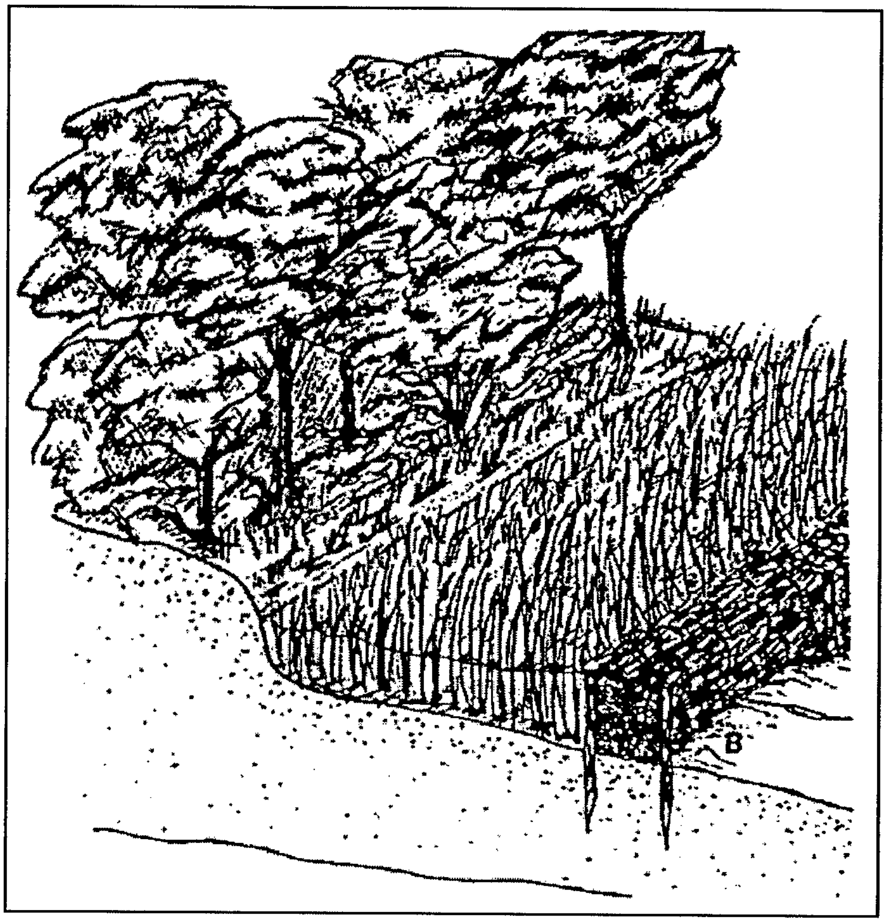

Figure 1. Schematic of branchbox breakwater with wetland vegetation planted shoreward of breakwater

Breakwater Treatments

One of the wave breakwater treatments consisted of a "branchbox breakwater," one modified from a European breakwater design shown in Figure 1. The breakwater was designed to be a temporary structure to diminish wave energy and provide time for plant establishment. Its purpose was to develop a stable slope for revegetation behind the breakwater. In summary, the breakwater generally consists of bundles of dead brush, called fascines, that are laid down between two rows of parallel poles. The poles are loosely driven at first with wire laced between the rows; then the poles with wire are firmly driven further into the lake bottom to secure the bundles of dead brush in the form of a breakwater composed of a brush wall. The 50-ft-long breakwater was positioned about 10 to 15 ft out from the bank and was planted behind with emergent aquatic vegetation.

The second breakwater treatment consisted of a coir geotextile breakwater that covered 130 ft of shoreline. The breakwater, like the one above, was designed to be temporary. It will diminish wave energy and will allow plants to be planted both behind and in it. The breakwater was constructed of nonwoven coir fiber made from coconut husks and bound by either a choice of woven coir rope or polyethylene rope. The demonstration breakwater was 20 in. in diameter and was bound by polyethylene rope for durability in a wave environment. The shoreward side of the breakwater was planted with emergent aquatic vegetation immediately adjacent to the breakwater, with live willow whips laid down and secured as a brush mattress, in accordance with methods described in Allen and Leech (1997). The coir breakwater with an incomplete brush mattress is shown during installation in Figure 2.

Other treatments

Three other treatments, each 130 ft in shoreline length, were used. These treatments consisted of securing the plant by means other than a wave breakwater. One treatment was composed of a "plant roll," a cylinder of emergent aquatic plant clumps in soil that is wrapped by burlap and secured by hog rings and placed in a trench. Several of these 8-in.-diam and 10-ft-long cylinders were buried end to end to form a horseshoe-shaped perimeter around the 130-ft-long shoreline to be protected. Rooted sprigs of emergent aquatic vegetation were planted inside this perimeter. The plant roll was designed to give the enclosed planted vegetation additional protection from waves by securing it as part of a larger mass of soil and plant materials; individual plants are not as easily

Figure 2. Breakwater made from a coir geotextile roll with workshop participants installing a brush mattress made from willow

eroded away. Also, the burlap cylinder facilitates the use and containment of slow-release fertilizer to give the plants a nutritional advantage. The perimeter of plant rolls was designed to act as a toe to guard against undercutting by waves and to provide some stability to other individual sprigs of emergent aquatic vegetation planted in its leeward direction or shadow zone. In addition to the plant rolls, three rows of contour wattling were placed slightly shoreward of the plant rolls. Wattling is a cigar-shaped bundle of live, shrubby material made from species that root very quickly from the stem, such as willow (Allen and Leech 1997). Bundles are often laid end to end on contour across the slope as they were in this demonstration. One row was placed about 1 ft below conservation pool and two rows were spaced about 6 ft apart on respective contours slightly above the other row.

The next treatment was installed on a 130-ft reach just to the east of the previous plant-roll treatment. It consisted of an installation of emergent aquatic plants just lakeward of dormant live willow poles and cuttings. There was no breakwater, geotextile roll, or plant rolls for wave protection; however, emergent aquatic plants were inserted and grown in a 2-in.-thick nonwoven coir geotextile mat. The plants were installed in a matrix of coir fibers to facilitate root development. Several 4- by 4-ft patches of these mats were installed in a checkerboard pattern, and each mat was backfilled with soil to fill the voids. Because of possible herbivory problems from carp and geese, about one-third of these patches were fitted with a perimeter of geosynthetic grid, similar to those commonly used for safety fences around construction sites. Thus, they served as exclosures to geese and carp. Figure 3 shows one of these patches with the fence around it. Landward of the 4- by 4-ft patches of emergent aquatic plants, both dormant willow poles and willow cuttings were planted. A backhoe with an attached "stinger," as described by Hoag (1994), facilitated the use of 8- to 10-ft long willow poles (Figure 4).

The last treatment installed also covered a 130-ft reach of shoreline and was the treatment most protected from wave action. The configuration of the shoreline and its existence farther up and to the east along the peninsula provided more protection from the wind and boat activity. Here, WES believed that both emergent aquatic plants and submersed aquatic vegetation could work without either the protection of breakwaters or any extra anchoring device, such as a geotextile mat or plant roll. This treatment also met one of the MDC objectives of restoring both emergent and submersed aquatic vegetation for the benefit of a wider variety of organisms that are dependent on such plants. As in the previous treatment, dormant willow poles and cuttings were planted shoreward of these plants. Emergent aquatic vegetation was planted by transplanting sprigs directly into the lake bed, whereas clumps of submersed aquatic

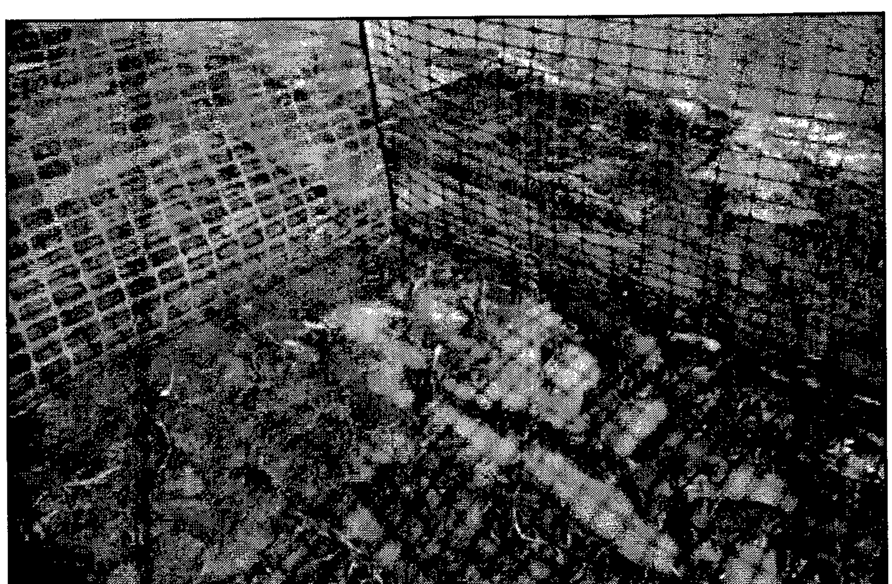

Figure 3. Patch of emergent aquatic plants immediately after planting in a coir geotextile mat. Geosynthetic grid fence surrounding patch serves as a geese and carp exclosure

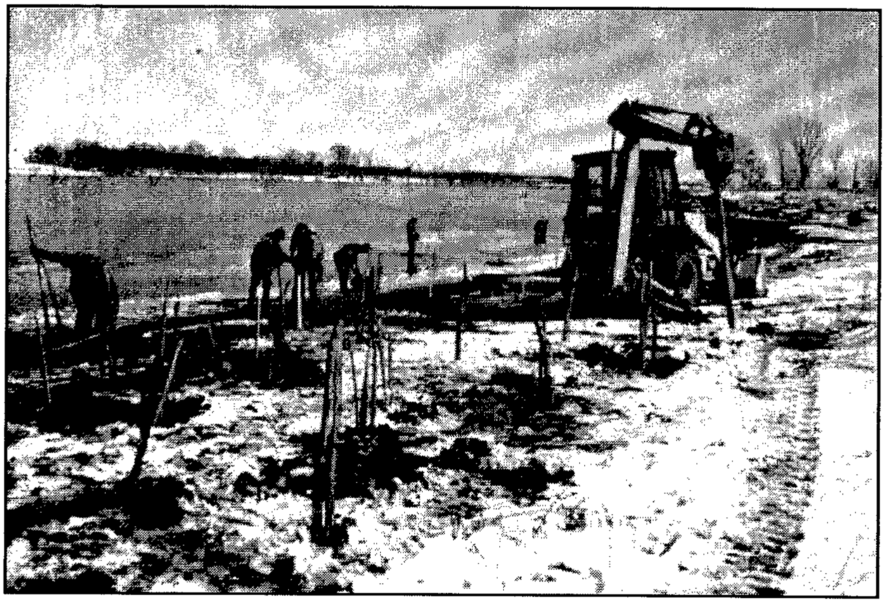

Figure 4. Dormant willow posts being installed with the aid of a backhoe mounted with a "stinger"

Figure 5. Submersed aquatic vegetation, such as coontail, being deposited in shallow water

vegetation, such as coontail (*Ceratophyllum demersum*) were simply deposited in about 1 to 2 ft of water (Figure 5).

Preliminary Results, Discussion, and Conclusions

The demonstration treatments were revisited in August 1998 by Corps personnel. Both areas behind each breakwater type, the branchbox and the coir geotextile roll, were capturing sediment and essentially reclaiming eroded shoreline. Particularly, new vegetative sprouts were occurring in the brush mattress behind the roll. These included both young willow and other emergent aquatic plants such as broad-leaved arrowhead (*Sagittaria latifolia*) (Figure 6). Other emergent aquatic plants were observed shoreward of the roll (Figure 7). The coir roll breakwater was intended to be planted by inserting sprigs of emergent aquatic plants in it. This action was postponed until lake levels were high enough to wet the roll so plants would not dry out. This planting may take place in the spring of 1999.

These two breakwater treatments, so far, are controlling erosion and are serving as protected areas for plant development. Construction of the branchbox breakwater was labor-intensive and would normally result in more expense, even though structural components such as posts and dead brush were inexpensive. Such labor-intensive alternatives, however, may lend themselves to projects where volunteer labor is available. Other less labor-intensive breakwaters are being planned, such as those built with rows of round haybales.

Treated areas without breakwaters were most noticeable by the occurrence of emergent aquatic plants in the exclosures, most notably pickerel weed (*Pontederia cordata*), three-square (*Scirpus americanus*), and other bulrush species (*Scirpus* spp.) (Figure 8). Where exclosures were not present, aquatic plants were scarce. The exclosures probably prevented the plants from being extirpated by both geese and carp. Carp are abundant in the reservoir, particularly shallow areas, and the reservoir is noted for its large population of geese, which graze on aquatic vegetation.

Woody dormant willow posts were observed earlier in the growing season to have sprouting stems and leaves but were noted in August 1998 to have dead sprouts. This phenomenon often occurs in larger, woody posts because the sprouts grow, exhausting carbohydrates in the stem itself before root production is adequate to support top-growth. Later,

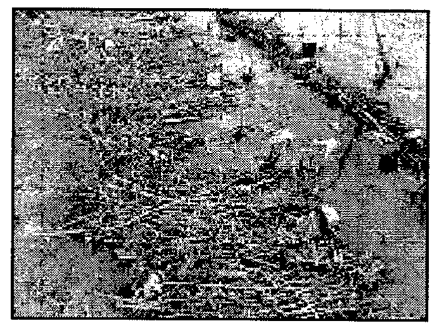

Figure 6. Brush mattress behind coir geotextile roll showing sprouts of willow and arrowhead

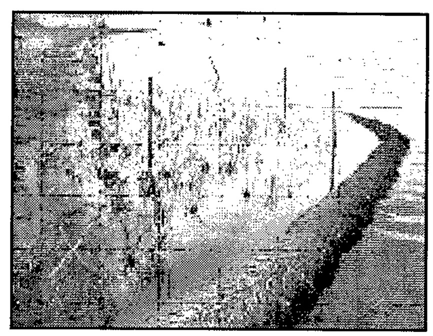

Figure 7. Aquatic plants emerging behind wave breakwater made from coir geotextile roll

Figure 8. Emergent aquatic plants such as pickerel weed and three-square within an exclosure

often in the second growing season, willow posts can be seen with stem sprouts from the bases after roots have developed. The upper part of the old posts may appear to be dead. Most of the smaller, live willow cuttings mixed among the willow posts were observed to be green and had sprouting stems and leaves.

Monitoring will continue, at least qualitatively, during the spring and summer of 1999 to ascertain if the bioengineering treatments are continuing to control erosion and provide aquatic and terrestrial habitat. Lake levels rose dramatically above conservation pool due to major flooding during September 1998, possibly before plants went completely into dormancy. This flooding could have had a detrimental effect on plant survival if emergent aquatic plants and woody plants were completely submerged for a long time during an active growth state. Observations during the growing season of 1999 will determine whether or not the 1998 plantings have survived and continue to grow and spread.

Acknowledgments

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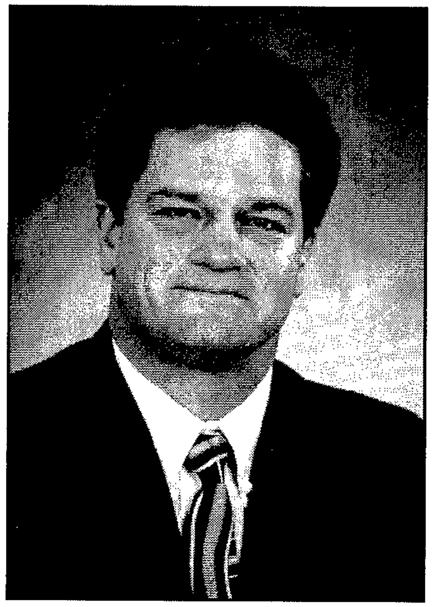

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